PB-239 640

WILLOW RESERVOIR, ONEIDA COUNTY, WISCONSIN

Pacific Northwest Environmental Research Laboratory

Prepared for:

National Environmental Research Center
Wisconsin National Guard
Wisconsin Department of Natural Resources

October 1974

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

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REPORT
ON
WILLOW RESERVOIR
ONEIDA COUNTY
WISCONSIN

EPA REGION V

WORKING PAPER No. 56

WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

OCTOBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wisconsin Department of Natural Resources for professional involvement and to the Wisconsin National Guard for conduct of the tributary sampling phase of the Survey.

Francis H. Schraufnagel, Acting Assistant Director, and Joseph R. Ball of the Bureau of Water Quality, and Donald R. Winter, Lake Rehabilitation Program, provided invaluable lake documentation and counsel during the Survey. Central Office and District Office personnel of the Department of Natural Resources reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

Major General James J. Lison, Jr., the Adjutant General of Wisconsin, and Project Officer CW-4 Donald D. Erickson, who directed the volunteer efforts of the Wisconsin National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

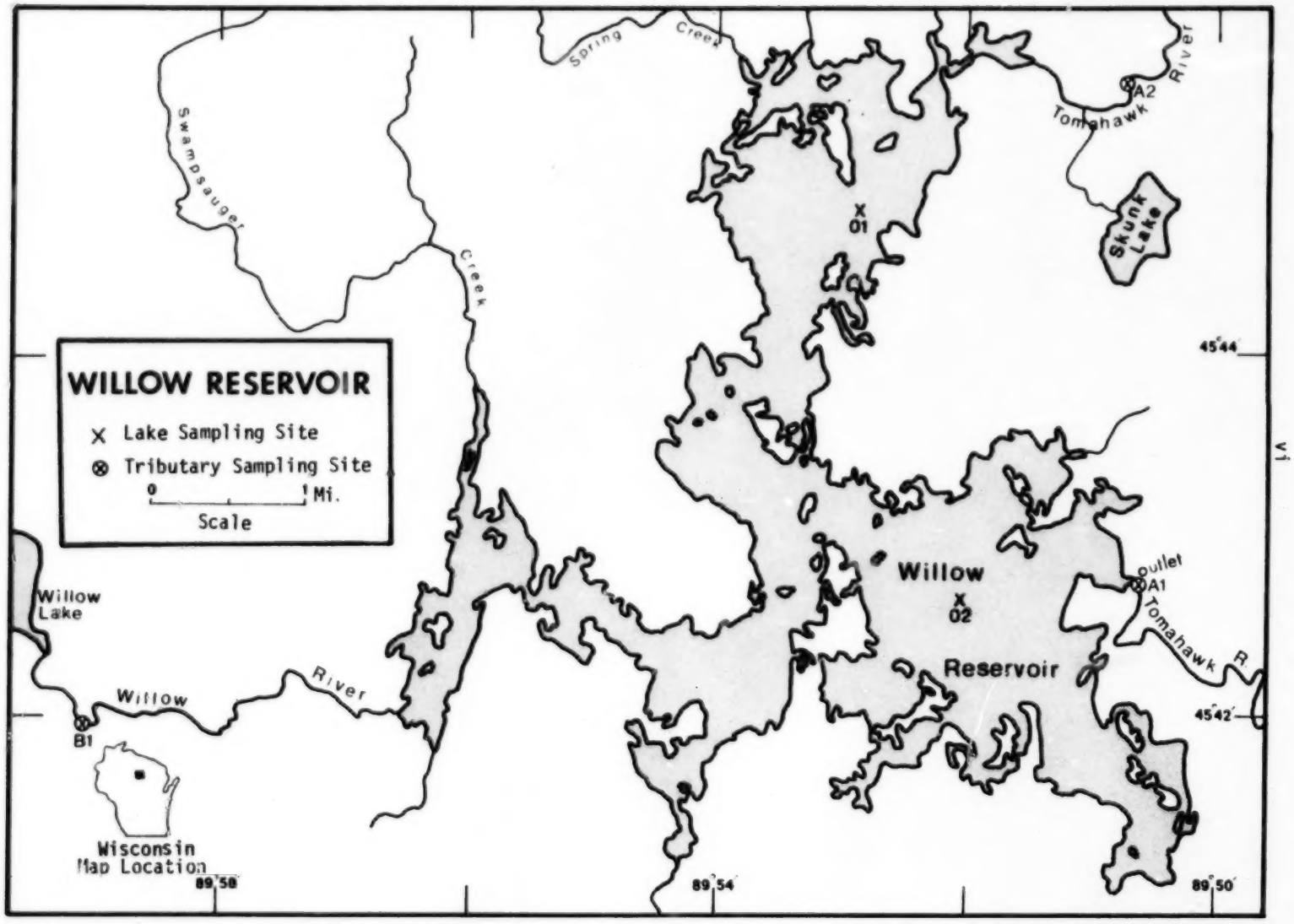
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WISCONSIN

LAKE NAME	COUNTY
Altoona	Eau Claire
Beaver Dam	Barron
Beaver Dam	Dodge
Big Eau Pleine	Marathon
Browns	Racine
Butte des Morts	Winnebago
Butternut	Price, Ashland
Castle Rock Flowage	Juneau
Como	Walworth
Crystal	Vilas
Delavan	Walworth
Eau Claire	Eau Claire
Elk	Price
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
Long	Price
Middle	Walworth
Nagawicka	Waukesha
Oconomowoc	Waukesha
Okauchee	Waukesha
Petenwell Flowage	Juneau
Pewaukee	Waukesha
Pigeon	Waupaca
Pine	Waukesha
Poygan	Winnebago, Waushara
Rock	Jefferson
Rome Pond	Jefferson, Waukesha
Round	Waupaca
Shawano	Shawano

LAKE NAME	COUNTY
Sinnissippi	Dodge
Swan	Columbia
Tainter	Dunn
Tichigan	Racine
Townline	Oneida
Trout	Vilas
Wapogassett	Polk
Wausau	Marathon
Willow	Oneida
Winnebago	Winnebago, Fond Du Lac, Calumet
Wisconsin	Columbia
Wissota	Chippewa
Yellow	Burnett


WILLOW RESERVOIR
X Lake Sampling Site
⊗ Tributary Sampling Site
0 1 Mi.
Scale
Swampsauger Creek
Spring Creek
Tomahawk River
A2
X 01
Skunk Lake
45°44'
Willow Lake
Willow River
B1
Willow
X 02
Reservoir
Outlet A1
Tomahawk R.
45°42'
Wisconsin
Map Location
89°58'
89°54'
89°50'

WILLOW RESERVOIR

STORET NO. 5574

I. CONCLUSIONS

A. Trophic Condition:

As far as is known, there are no records of occurrence of aquatic nuisances in Willow Reservoir. Survey data indicate the Reservoir is probably eutrophic, but personnel of the Wisconsin Department of Natural Resources consider the Reservoir to be mesotrophic.

B. Rate-Limiting Nutrient:

Algal assay results are not considered reliable. Lake data indicate nitrogen limitation at all sampling times.

C. Nutrient Controllability:

During the sampling year, Willow Reservoir received a phosphorus load at a rate less than that proposed by Vollenweider (in press) as "dangerous" but more than the "permissible" rate; i.e., a mesotrophic rate (see page 15). However, almost all of the phosphorus load is attributable to non-point, and hence uncontrollable. sources.

Apparently, the Minoqua Sanitary District discharge, some 45+ stream miles away, had little effect on Willow Reservoir during the sampling year. Note that the phosphorus load of the Tomahawk River per square mile was essentially the same as that of the unimpacted Willow River (see page 15).

It is concluded that point-source control would have little effect on the trophic condition of Willow Reservoir.

II. INTRODUCTION

Willow Reservoir was formed by the impoundment of the Tomahawk River in 1927 by the Wisconsin Valley Improvement Company for storage and low flow augmentation. It is located in the headwaters portion of the upper Wisconsin River drainage basin in glaciated north central Wisconsin. Most of the area is wooded, and recreation is said to be the base of the economy.

Recreational uses of Willow Reservoir include swimming, boating, and fishing. Game fish present are muskellunge, northern pike, walleyes, largemouth bass, and panfish. Six resorts and eight boat liveries offer services.

Although most of the shoreline is privately owned, public access is provided.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry:

1. Surface area: 5,134 acres.
2. Mean depth: 15 feet.
3. Maximum depth: 22 feet.
4. Volume: 77,000 acre/feet.
5. Mean hydraulic retention time: 119 days.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Tomahawk River	190.0 mi^2	185.2 cfs
Willow River	70.3 mi^2	72.0 cfs
Minor tributaries & immediate drainage -	58.7 mi^2	67.9 cfs
Totals	319.0 mi^2	325.1 cfs

2. Outlet -

Tomahawk River	327.0 mi^2**	325.1 cfs**

C. Precipitation†:

1. Year of sampling: 43.3 inches.
2. Mean annual: 31.3 inches.

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* Drainage areas are accurate within ±0.5%; mean daily flows are accurate within ±40%; mean monthly flows are accurate within ±35%; and normalized monthly flows are accurate within ±35%.
** Includes are of lake; outflow adjusted to equal sum of inflows.
† See Working Paper No. 1, "Survey Methods".

IV. LAKE WATER QUALITY SUMMARY

Willow Reservoir was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the two stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 11 feet at station 1 and 15 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES		
Temperature (Cent.)	3.4	3.5	3.5	3.6
Dissolved oxygen (mg/l)	10.8	11.0	10.8	11.6
Conductivity (μmhos)	70	75	72	80
pH (units)	6.7	6.7	6.8	6.8
Alkalinity (mg/l)	28	30	30	33
Total P (mg/l)	0.023	0.027	0.030	0.032
Dissolved P (mg/l)	0.014	0.018	0.020	0.021
NO_2 + NO_3 (mg/l)	0.080	0.108	0.120	0.140
Ammonia (mg/l)	0.080	0.092	0.090	0.110
		ALL VALUES		
Secchi disc (inches)	36	42	40	54

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/25/72	1. Melosira	3,765
	2. Dinobryon	1,175
	3. Tabellaria	723
	4. Polycystis	663
	5. Fragilaria	512
	Other genera	1,626
	Total	8,464
08/23/72	1. Melosira	1,302
	2. Anabaena	597
	3. Cyclotella	470
	4. Fragilaria	380
	5. Asterionella	235
	Other genera	615
	Total	3,599
11/04/72	1. Flagellates	2,108
	2. Dinobryon	331
	3. Navicula	120
	4. Melosira	90
	5. Achnanthes	75
	Other genera	469
	Total	3,193

2. Chlorophyll *a* -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
06/25/72	01	12.9
	02	15.6
08/23/72	01	13.4
	02	5.8
11/04/72	01	4.1
	02	3.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.002	0.094	0.1
0.006 P	0.008	0.094	1.3
0.012 P	0.014	0.094	3.0
0.024 P	0.026	0.094	3.0
0.060 P	0.062	0.094	5.0
0.060 P + 10.0 N	0.062	10.094	31.6
10.0 N	0.002	10.094	0.1

2. Discussion -

The assay results are not considered reliable because of the significant loss of both phosphorus and nitrogen between the time the sample was collected and the time the assay was begun. One half of the phosphorus originally present was lost, and inorganic nitrogen was reduced from 200 µg/l to 94 µg/l.

On the basis of other assays, had the nutrient loss not occurred, the probable control yield would have been a moderately high 7 mg/l dry weight.

D. Trophic Condition:

As far as is known, there are no records of the occurrence of aquatic nuisance conditions in Willow Reservoir. Survey limnologists did not observe excessive algal growths at any time; but of the 46 Wisconsin lakes studied, 21 had less mean chlorophyll a, and blue-green alga were present in two of the three phytoplankton samples collected.

Nutrient concentrations in the reservoir were comparatively low; 31 of the 46 Wisconsin lakes had higher mean total phosphorus, 32 had higher mean dissolved phosphorus, and only six had lower mean inorganic nitrogen. The nutrient concentrations observed are believed to be due to moderate loadings and the relatively short detention time of about four months.

Twenty-two of the Wisconsin lakes had greater Secchi disc transparencies. Although turbidity and/or color may have influenced this, it is again noted that 21 of the lakes studied had less chlorophyll a.

Although lake sampling was not intensive, some depression of dissolved oxygen with depth occurred consistently at station 2 in the main body of the reservoir.

On the basis of Survey data, it is concluded that the reservoir is in a borderline eutrophic condition; however, Department of Natural Resources personnel consider the reservoir to be mesotrophic (Schraufnaugel, 1974).

V. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Wisconsin National Guard collected a monthly near-surface grab sample from each of the tributary sites indicated on the map (page vi) except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1972, and was completed in August, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Wisconsin District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, tributary nutrient loads were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the nutrient loads of the Willow River, in lbs/mi^2/year, and multiplying by the ZZ area in mi^2.

The Minoqua Sanitary District waste treatment facility discharges to the Tomahawk River about 45 miles upstream from Willow Reservoir and, hence, was outside the 25-mile limit of the Survey. This source appears to have little effect on Willow Reservoir (see discussion, page 1).

---

* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Minoqua SD	1,280*	Act. sludge	0.128**	Tomahawk River

2. Industrial - None known

* Estimated on basis of flow (100 gal/capita/day).
** McKersie, et al., 1970.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Tomahawk River	11,960	56.3
Willow River	4,640	21.8
b. Minor tributaries & immediate drainage (non-point load) -	3,870	18.1
c. Known municipal STP's -		
Minoqua SD	?	-
d. Septic tanks* -	50	0.2
e. Industrial - None known	-	-
f. Direct precipitation** -	800	3.7
Total	21,230	100.0

2. Outputs -

Lake outlet - Tomahawk River 19,220

3. Net annual P accumulation - 2,210 pounds

* Six resorts and 25 dwellings on lakeshore; see Working Paper No. 1.
** Estimated; see Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Tomahawk River	223,420	48.2
Willow River	102,650	22.2
b. Minor tributaries & immediate drainage (non-point load) -	85,700	18.5
c. Known municipal STP's -		
Minoqua SD	?	-
d. Septic tanks* -	2,000	0.4
e. Industrial - None known	-	-
f. Direct precipitation** -	49,460	10.7
Total	463,230	100.0

2. Outputs -

Lake outlet - Tomahawk River 515,010

3. Net annual N loss - 51,780 pounds

* Six resorts and 25 dwellings on lakeshore; see Working Paper No. 1.
** Estimated; see Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Sub-drainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Tomahawk River	63	1,176
Willow River	66	1,460

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those porposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	4.2	0.4	90.2	loss*
grams/m^2/yr	0.47	0.05	10.1	-

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Willow Reservoir:

"Dangerous" (eutrophic rate)	0.72
"Permissible" (oligotrophic rate)	0.36

* There was an apparent loss of nitrogen during the sampling year. This may have been due to solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, or (probably) underestimation of minor tributary and immediate drainage contributions. Whatever the cause, a similar loss of nitrogen has been observed at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication and Lake Restoration Branch.

VI. LITERATURE REVIEWED

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VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5574 WILLOW RESERVOIR

TOTAL DRAINAGE AREA OF LAKE 327.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
5574A1	327.00	206.35	206.35	353.74	648.43	412.80	373.40	255.38	255.38	314.44	314.44	314.44	245.66	325.08
5574A2	190.00	91.00	91.00	210.00	480.00	280.00	220.00	130.00	130.00	160.00	160.00	160.00	110.00	185.18
5574B1	70.30	20.00	20.00	80.00	280.00	140.00	86.00	34.00	34.00	50.00	48.00	48.00	24.00	71.95
5574ZZ	66.70	18.00	18.00	74.00	270.00	130.00	81.00	32.00	32.00	48.00	45.00	45.00	23.00	67.94

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 327.00
SUM OF SUB-DRAINAGE AREAS = 327.00

TOTAL FLOW IN = 3902.00
TOTAL FLOW OUT = 3900.81

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5574A1	9	72	290.00	24	205.00				
	10	72	290.00						
	11	72	600.00						
	12	72	720.00	9	750.00				
	1	73	560.00						
	2	73	460.00	10	460.00				
	3	73	130.00	10	110.00				
	4	73	140.00	7	64.00	24	306.00		
	5	73	900.00	6	1250.00	29	919.00		
	6	73	420.00	23	345.00				
	7	73	530.00	28	639.00				
	8	73	360.00	27	242.00				
5574A2	9	72	150.00	24	110.00				
	10	72	250.00						
	11	72	250.00						
	12	72	140.00	9	160.00				
	1	73	210.00						
	2	73	140.00	10	150.00				
	3	73	800.00	10	570.00				
	4	73	430.00	7	290.00	24	330.00		
	5	73	640.00	6	730.00	29	480.00		
	6	73	180.00	23	140.00				
	7	73	110.00	28	120.00				
	8	73	130.00	27	100.00				

TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5574 WILLOW RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
557481	9	72	48.00	24	36.00				
	10	72	140.00						
	11	72	160.00						
	12	72	24.00	9	27.00				
	1	73	39.00						
	2	73	18.00	10	20.00				
	3	73	290.00	10	170.00				
	4	73	240.00	7	160.00	24	180.00		
	5	73	310.00	6	360.00	29	180.00		
	6	73	70.00	23	52.00				
	7	73	27.00	28	32.00				
	8	73	31.00	27	27.00				
5574ZZ	9	72	46.00	24	34.00				
	10	72	130.00						
	11	72	160.00						
	12	72	22.00	9	24.00				
	1	73	36.00						
	2	73	16.00	10	18.00				
	3	73	299.00	10	160.00				
	4	73	240.00	7	160.00	24	180.00		
	5	73	300.00	6	340.00	29	170.00		
	6	73	66.00	23	50.00				
	7	73	26.00	28	30.00				
	8	73	29.00	27	26.00				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

557401
45 44 54.0 089 53 12.0
WILLOW RESERVOIR
55 WISCONSIN

11EPALES
3

2111202
0013 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/25	16 55	0000	18.2	9.5	48	70	7.50	27	0.050	0.050	0.026	0.019
	16 55	0010	18.0	8.2		70	7.50	26	0.040	0.040	0.027	0.018
72/08/23	15 45	0000			36	79	6.50	28	0.050	0.100	0.049	0.025
	15 45	0004	21.3	5.0		78	6.50	29	0.080	0.120	0.050	0.027
	15 45	0008	20.8	5.1		79	6.50	28	0.050	0.090	0.054	0.033
72/11/04	16 55	0000			40	80	6.70	32	0.090	0.090	0.023	0.015
	16 55	0004	3.4	10.8		80	6.70	33	0.080	0.080	0.024	0.016
	16 55	0011	3.4	10.9		78	6.70	32	0.090	0.080	0.025	0.014

2

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/25	16 55	0000	12.9J
72/08/23	15 45	0000	13.4J
72/11/04	16 55	0000	4.1J

J* VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

557402
45 42 48.0 089 52 00.0
WILLOW RESERVOIR
55 WISCONSIN

11EPALES 2111202
3 0017 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/25	18 05	0000	19.0	9.7	54	50K	7.70	20	0.040	0.040	0.030	0.022
	18 05	0015	17.2	8.0		50K	7.50	20	0.040	0.030	0.028	0.021
72/08/23	15 20	0000			38	70	6.90	29	0.050	0.090	0.025	0.016
	15 20	0004	21.2	6.7		70	6.95	29	0.050	0.070	0.026	0.017
	15 20	0014	20.8	5.9		70	6.90	28	0.060	0.100	0.035	0.017
72/11/04	15 35	0000			36	72	6.80	28	0.120	0.100	0.032	0.021
	15 35	0004	3.6	11.6		70	6.80	28	0.130	0.090	0.031	0.020
	15 35	0015	3.6	10.8		72	6.80	28	0.140	0.110	0.030	0.021

22

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/25	18 05	0000	15.6J
72/08/23	15 20	0000	5.8J
72/11/04	15 35	0000	3.2J

K= VALUE KNOWN TO BE LESS THAN INDICATED

J= VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/02

5574A1 LS5574A1
45 43 00.0 089 51 00.0
TOMAKAWK RIVER
55 MCCORD 15
O/WILLOW RES
CO HWY BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/24	11 00		0.077	1.250	0.083	0.008	0.042
72/11/05	09 30		0.126	0.690	0.044	0.012	0.037
72/12/09	10 30		0.090	0.930	0.023	0.015	0.050
73/01/13	11 00		0.103	0.560	0.070	0.009	0.020
73/02/10	10 00		0.138	0.440	0.080	0.019	0.025
73/03/10	11 00		0.130	0.400	0.063	0.015	0.030
73/04/07	10 00		0.075	0.732	0.014	0.007	0.025
73/04/24	13 00		0.010K	0.330	0.013	0.005K	0.025
73/05/06	15 00		0.035	0.420	0.020	0.010	0.020
73/05/29	10 00		0.010K	0.350	0.029	0.005K	0.020
73/06/23	15 00		0.021	2.310	0.460	0.100	0.145
73/07/28	11 00		0.011	0.630	0.016	0.007	0.040
73/08/27			0.010K	0.440	0.048	0.009	0.020

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/02

5574A2 LS5574A2
45 45 30.0 089 50 30.0
TOMAHAWK RIVER
55 15 LAC DU FLAMBE
1/WILLOW RESERVOIR
CO HWY 5.5 MI WSW OF HAZELHURST
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/24	11 30		0.181	0.500	0.145	0.026	0.050
72/11/05	10 00		0.036	0.390	0.016	0.007	0.025
72/12/09	11 00		0.083	0.370	0.010	0.010	0.020
73/01/13	10 00		0.105	0.400	0.054	0.009	0.020
73/02/10	11 00		0.138	0.360	0.042	0.013	0.025
73/03/10	12 00		0.160	0.420	0.064	0.014	0.025
73/04/07	11 00		0.063	0.600	0.012	0.011	0.020
73/04/24	12 00		0.010K	0.400	0.005K	0.005K	0.025
73/05/06	15 00		0.010K	1.120	0.030	0.008	0.025
73/05/29	13 00		0.010K	0.880	0.024	0.005K	0.020
73/06/23	12 00		0.025	0.600	0.105	0.030	0.075
73/07/28	14 00		0.032	0.460	0.008	0.019	0.050
73/08/27			0.010K	0.500	0.090	0.015	0.035

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/10/02

5574R1 LS5574R1
45 42 00.0 089 59 00.0
WILLOW RIVER
55 15 MCCORD
T/WILLOW RESERVOIR
CO HWY T 10 MI N OF TRIPOLI
11FPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/24	13 00		0.257	1.100	0.155	0.014	0.075
72/11/05	11 00		0.100	0.720	0.026	0.011	0.030
72/12/09	13 00		0.088	0.780	0.063	0.014	0.032
73/01/13	12 00		0.120	0.900	0.132	0.013	0.035
73/02/10	12 05		0.160	0.580	0.092	0.012	0.025
73/03/10	13 30		0.200	0.630	0.083	0.013	0.025
73/04/07			0.030	0.460	0.011	0.005K	0.150
73/04/24	15 00		0.025	0.770	0.007	0.005K	0.020
73/05/06	11 00		0.010K	0.500	0.022	0.007	0.020
73/05/29	15 00		0.014	0.520	0.029	0.005K	0.025
73/06/23	10 00		0.013	0.690	0.096	0.016	0.035
73/07/24	15 30		0.010K	0.360	0.024	0.025	0.055
73/08/27			0.010K	0.460	0.050	0.009	0.025

K VALUE KNOWN TO BE LESS THAN INDICATED